2. SUMMARY OF RESULTS

The data presented in Table 2.1 summarizes the emission concentration results for each compound evaluated at each furnace exhaust. The data presented in Table 2.2 summarizes the mass emission rate results for each compound evaluated at each furnace exhaust. The particulate matter results for each furnace are also summarized on pages 5-7 in printouts titled "Method 1-5 - Summary of Results". The hexavalent chromium results for each furnace are also summarized on pages 8-10 in printouts titled "Methods 1-4 & Hexavalent Chromium - Summary of Results".

Table 2.1. Summary of emission test results collected at Ball-InCon Glass Packaging in Seattle, Washington on December 11-13, 1989.

Location Run #	Dilution Corrected Partic. Matter gr/dscf	Hex. Chromium ppm	Sulfur Dioxide ppm	Nitrogen Oxides ppm	Carbon Monoxide ppm
Furnace #3					
Run 1	0.071	0.002	19	510	<3
Run 2	0.065	0.001	34	496	<3
Run 3	0.072	0.001	44	501	<3
Average	0.069	0.001	32	502	<3
Furnace #4					
Run 1	0.065	0.002	14	867	<3
Run 2	0.066	0.004	14	898	<3
Run 3	0.047	0.007	13	859	<3
Average	0.059	0.004	14	875	<3
Furnace #5					
Run 1	0.103	0.008	8	914	<3
Run 2	0.112	0.004	9	950	<3
Run 3	0.117	<0.001	8	925	<3
Average	0.111	0.004	8	930	<3

The particulate matter emission concentration in Table 2.1 (corrected for dilution air) is presented in units of grains per dry standard cubic foot (gr/dscf). The gaseous emissions are presented in concentration units of parts per million (ppm). The sulfur dioxide and nitrogen oxides (as NO_2) sample times correspond to those of the Method 5 runs, with the exception of Furnace #4, runs 2 and 3, which correspond to the times when hexavalent chromium samples were being collected during runs 2 and 3 at Furnace #4.

Table 2.2. Summary of mass emissions from tests performed at Ball-InCon Glass Packaging in Seattle, Washington on December 11-13, 1989.

Location Run #	Partic. Matter lb/hr	Hex. Chromium mg/hr	Sulfur Dioxide lb/hr	Nitrogen Oxides lb/hr	Carbon Monoxide lb/hr
Furnace #3					
Run 1	5.14	145.1	3.79	73.1	<0.3
Run 2	4.74	97.6	6.78	71.1	<0.3
Run 3	5.63	61.6	9.01	73.8	<0.3
Average 1.08 #/T	5.17	101.4	6.53	72.7	<0.3
Furnace #4					
Run 1	6.69	167.7	3.32	147.9	<0.3
Run 2	7.92	442.3	3.81	175.8	<0.3
Run 3	5.26	607.8	3.17	150.8	<0.3
Average 1.23 #/T	6.62	405.9	3.43	158.2	<0.3
Furnace #5					
Run 1	5.21	505.2	1.20	99.0	<0.3
Run 2	5.20	234.9	1.31	99.2	<0.3
Run 3	5.48	5.7	1.16	96.5	<0.3
Average 1.00 #/T	5.30	248.6	1.22	98.2	<0.3

The mass emission rates of particulate matter, sulfur dioxide, nitrogen oxides (as NO_2), and carbon monoxide are presented in pounds per hour (lb/hr). The mass emission rate of hexavalent chromium is presented in units of milligrams per hour (mg/hr). Computer printouts of the results from these tests are included in Appendix A of this report.

METHODS 1-4 & HEXAVALENT CHROMIUM - SUMMARY OF RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME: BICR3SUM
CLIENT: BALL-INCON GLASS PACKAGING CORP.
LOCATION: SEATTLE, WASHINGTON
SAMPLE SITE: #3 FURNACE STACK
OPERATORS: J. GUENTHOER
CONTACT: M. GRIDLEY

	RUN #1	RUN #2	RUN #3	AVERAGE
LAB #:	922680	922682	922684	
DATE:	12/11	12/11	12/11	
START TIME:	10:49	12:20	13:50	
STOP TIME:	11:49	13:20	14:50	
SAMPLE TIME (Minutes):	60.0	60.0	60.0	
VOLUME SAMPLED (Cubic Feet):	31.413	47.383	47.280	42.025
VOLUME SAMPLED (Dry Std. Cubic Feet):	33.244	49.513	49.137	43.965
VOLUME SAMPLED (Dry Std. Cubic Meters):	0.941	1.402	1.392	1.245
STACK GAS MOISTURE (Percent):	7.30	6.17	4.51	5.99
BAROMETRIC PRESURE (Inches of Hg):	30.35	30.35	30.31	30.34
STATIC PRESSURE (Inches of H2O):	-0.30	-0.30	-0.30	-0.30
STACK PRESSURE (Inches of Hg):	30.33	30.33	30.29	30.32
STACK TEMPERATURE (Degrees F.):	327.2	325.8	325.8	326.3
STACK TEMPERATURE (Degrees R.):	787.2	785.8	785.8	786.3
CARBON DIOXIDE (Percent):	2.0	2.4	2.9	2.4
OXYGEN (Percent):	16.5	17.3	17.3	17.0
CARBON MONOXIDE (Percent):	0	0	0	0
MOLECULAR WEIGHT (Dry, Lb/Lb-Mole):	28.98	29.08	29.16	29.07
MOLECULAR WEIGHT (Wet, Lb/Lb-Mole):	28.18	28.39	28.65	28.41
AVERAGE VELOCITY HEAD (Inches of H2O):	0.347	0.342	0.335	0.341
PITOT TUBE Cp:	0.840	0.840	0.840	
VELOCITY (Feet/Second):	40.58	40.12	39.54	40.08
STACK DIAMETER (Inches):	49.00	49.00	49.00	
STACK AREA (Square Feet):	13.095	13.095	13.095	
AIRFLOW (Dry Std. Cubic Feet per Min.):	20097.7	20142.7	20176.4	20138.9
AIRFLOW (Actual Cubic Feet per Min.):	31886.4	31521.9	31064.7	31491.0
NOZZLE DIAMETER (Inches):	0.254	0.313	0.313	
ISOKINETICS (Percent):	103	100	100	101
HEXAVALENT CHROMIUM CONC. (mg/dscm):	0.004	0.003	0.002	0.003
TOTAL HEX. CHROMIUM IN SAMPLE (ppm):	0.002	0.001	0.001	0.001
HEX. CHROMIUM EMISSION RATE (mg/hr):	145.1	97.6	61.6	101.4

METHODS 1-4 & HEXAVALENT CHROMIUM - SUMMARY OF RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME: BICR4SUM
CLIENT: BALL-INCON GLASS PACKAGING CORP.
LOCATION: SEATTLE, WASHINGTON
SAMPLE SITE: #4 FURNACE STACK
OPERATORS: J. GUENTHOER
CONTACT: M. GRIDLEY

	RUN #1	RUN #2	RUN #3	AVERAGE
LAB #:	923140	923142	923144	
DATE:	12/13	12/13	12/13	
START TIME:	09:08	10:39	12:08	
STOP TIME:	10:08	11:39	13:08	
SAMPLE TIME (Minutes):	60.0	60.0	60.0	
VOLUME SAMPLED (Cubic Feet):	53.897	58.357	52.757	55.004
VOLUME SAMPLED (Dry Std. Cubic Feet):	55.709	59.292	53.200	56.067
VOLUME SAMPLED (Dry Std. Cubic Meters):	1.578	1.679	1.507	1.588
STACK GAS MOISTURE (Percent):	6.89	5.17	5.48	5.85
BAROMETRIC PRESURE (Inches of Hg):	30.55	30.55	30.55	30.55
STATIC PRESSURE (Inches of H2O):	-1.30	-1.30	-1.30	-1.30
STACK PRESSURE (Inches of Hg):	30.45	30.45	30.45	30.45
STACK TEMPERATURE (Degrees F.):	573.8	565.3	576.8	572.0
STACK TEMPERATURE (Degrees R.):	1033.8	1025.3	1036.8	1032.0
CARBON DIOXIDE (Percent):	3.6	3.8	3.3	3.6
OXYGEN (Percent):	15.6	15.6	15.5	15.6
CARBON MONOXIDE (Percent):	0	0	0	0
MOLECULAR WEIGHT (Dry, Lb/Lb-Mole):	29.20	29.23	29.15	29.19
MOLECULAR WEIGHT (Wet, Lb/Lb-Mole):	28.43	28.65	28.54	28.54
AVERAGE VELOCITY HEAD (Inches of H2O):	1.422	1.570	1.280	1.424
PITOT TUBE Cp:	0.840	0.840	0.840	
VELOCITY (Feet/Second):	93.56	97.54	88.74	93.28
STACK DIAMETER (Inches):	41.50	41.50	41.50	
STACK AREA (Square Feet):	9.393	9.393	9.393	
AIRFLOW (Dry Std. Cubic Feet per Min.):	25525.6	27326.5	24505.0	25785.7
AIRFLOW (Actual Cubic Feet per Min.):	52730.7	54974.8	50012.4	52572.6
NOZZLE DIAMETER (Inches):	0.254	0.254	0.254	
ISOKINETICS (Percent):	97	97	97	97
HEXAVALENT CHROMIUM CONC. (mg/dscm):	0.004	0.010	0.015	0.010
TOTAL HEX. CHROMIUM IN SAMPLE (ppm):	0.002	0.004	0.007	0.004
HEX. CHROMIUM EMISSION RATE (mg/hr):	167.7	442.3	607.8	405.9

METHODS 1-4 & HEXAVALENT CHROMIUM - SUMMARY OF RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	BICR5SUM
CLIENT:	BALL-INCON GLASS PACKAGING CORP.
LOCATION:	SEATTLE, WASHINGTON
SAMPLE SITE:	#5 FURNACE STACK
OPERATORS:	J. GUENTHOER
CONTACT:	M. GRIDLEY

	RUN #1	RUN #2	RUN #3	AVERAGE
LAB #:	922807	922809	922811	
DATE:	12/12	12/12	12/12	
START TIME:	11:08	12:40	14:05	
STOP TIME:	12:08	13:40	15:05	
SAMPLE TIME (Minutes):	60.0	60.0	60.0	
VOLUME SAMPLED (Cubic Feet):	52.997	52.734	51.564	52.432
VOLUME SAMPLED (Dry Std. Cubic Feet):	54.841	54.456	53.048	54.115
VOLUME SAMPLED (Dry Std. Cubic Meters):	1.553	1.542	1.502	1.532
STACK GAS MOISTURE (Percent):	6.07	6.27	6.58	6.31
BAROMETRIC PRESURE (Inches of Hg):	30.59	30.59	30.55	30.58
STATIC PRESSURE (Inches of H2O):	-0.35	-0.35	-0.35	-0.35
STACK PRESSURE (Inches of Hg):	30.56	30.56	30.52	30.55
STACK TEMPERATURE (Degrees F.):	622.6	669.8	674.4	655.6
STACK TEMPERATURE (Degrees R.):	1082.6	1129.8	1134.4	1115.6
CARBON DIOXIDE (Percent):	3.4	3.7	3.7	3.6
OXYGEN (Percent):	15.8	15.5	15.5	15.6
CARBON MONOXIDE (ppm):	0	0	0	0
MOLECULAR WEIGHT (Dry, Lb/Lb-Mole):	29.18	29.21	29.21	29.20
MOLECULAR WEIGHT (Wet, Lb/Lb-Mole):	28.50	28.51	28.47	28.49
AVERAGE VELOCITY HEAD (Inches of H2O):	0.610	0.633	0.583	0.609
PITOT TUBE Cp:	0.840	0.840	0.840	
VELOCITY (Feet/Second):	62.54	65.05	62.67	63.42
STACK DIAMETER (Inches):	41.50	41.50	41.50	
STACK AREA (Square Feet):	9.393	9.393	9.393	
AIRFLOW (Dry Std. Cubic Feet per Min.):	16497.1	16406.8	15668.0	16190.6
AIRFLOW (Actual Cubic Feet per Min.):	35249.8	36662.5	35319.5	35743.9
NOZZLE DIAMETER (Inches):	0.313	0.313	0.313	
ISOKINETICS (Percent):	97	97	99	98
HEXAVALENT CHROMIUM CONC. (mg/dscm):	0.018	0.008	0.000	0.009
TOTAL HEX. CHROMIUM IN SAMPLE (ppm):	0.008	0.004	0.000	0.004
HEX. CHROMIUM EMISSION RATE (mg/hr):	505.2	234.9	5.7	248.6

3. METHODOLOGY REFERENCES

Sampling procedures specified in the July 1, 1988 Title 40 Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A, Methods 1-5, 6C, 7E, and 10 were followed throughout this project. Sampling and analysis procedures specified in the Puget Sound Air Pollution Control Agency (PSAPCA) "Particulate Source Test Procedures" adopted by the PSAPCA Board of Directors, August 11, 1983, in accordance with section 9.09 of Regulation I, PSAPCA, were utilized in conjunction with the EPA Method 5 procedures for "back-half" analysis for extracting condensable matter. Hexavalent chromium (Cr^{+6}) in the exhaust stream was sampled using procedures described in the California Air Resources Board (CARB) Method 425, which is a modified version of EPA Method 5. A paper titled "Method Development and Testing for Measurement of Source Levels of Hexavalent and Total Chromium" written by Daniel G. Bivins and W.G. DeWees and presented at the 80th annual APCA meeting was referenced to determine the appropriate test method. Analysis was performed using diphenylcarbazide photometric procedures (EPA Method 7196) detailed in a draft method titled "Determination of Hexavalent Chromium Emissions from Decorative and Hard Chrome Electroplating" dated July 26, 1988. Methodology suggested in the Environmental Protection Agency's (EPA's) Air Pollution Training Institute "Course 450 - Source Sampling for Particulate Pollutants" and quality assurance procedures outlined in the EPA's reference manual titled Quality Assurance Handbook for Air Pollution Measurement Systems, Volume 3, EPA-600/4-77-027b were used for supplemental information with respect to quality assurance and testing protocol.

4.5 Hexavalent Chromium Sampling

The sample train used for collecting hexavalent chromium (Cr^{+6}) samples was an EPA Method 5 design with modifications. A typical Method 5 sample train schematic is included as Figure 1 in Appendix C of this report. The sample train did not include a heated front-half filter. A quartz probe with an attached nozzle was inserted into the stack to draw a sample into the impingers. The probe was equipped with "S" type pitot tubes to measure velocity and a thermocouple sensor to measure the stack temperature at each sample point. The thermocouple probe was connected to a Fluke^{R} digital thermocouple indicator which is accurate to within $\pm$1 degree Fahrenheit. The condenser section of the sample train consisted of a modified Greenburg-Smith bubbler containing 100 milliliters (ml) of 0.1 N sodium hydroxide (NaOH) absorbing solution, a second impinger containing 100 ml of NaOH absorbing solution, an empty bubbler, a back-half filter holder containing a Teflon^{R} filter, and a final bubbler containing indicating silica gel desiccant. The condenser section was maintained at a temperature below 68° F by adding ice to the condenser section throughout sampling. The sample train was connected to a control box as described for the Method 5 sampling.

Stack condition measurements were made prior to collecting a sample. The appropriate sample nozzle was selected and isokinetic operating parameters were established utilizing a Hewlett-Packard programmable calculator. The sampling nozzle, probe and condenser section glassware were all cleaned and rinsed with dilute nitric acid and deionized water prior to assembling the sample train. The sample train was assembled and leak tested following the procedures outlined in Method 5. Ice was added to the condenser section. The sample nozzle was positioned in the stack at the first sample point. The sample pump was then turned on and the gas sampling rate was adjusted for isokinetic sampling.

Sampling proceeded isokinetically at each of the traverse points. Upon completion of the test the sample probe was removed from the stack and a post-test leak check was performed according to Method 5 procedures.

Following sample collection, the chromium samples were transferred to a temporary laboratory area for clean up. The back-half filters were transferred to glass petri dishes labeled with the sample date, client name and run number. These filters, along with an unused filter to be analyzed as a blank, were submitted to the Am Test laboratory for washing and hexavalent chromium analysis.

The contents of the nozzle, probe liner and connective glassware were quantitatively transferred to a glass storage container using 0.1 N NaOH. An iodine flask with a female ball joint end was attached to the male ball joint end of the probe to assure that no material collected inside the glassware was lost during the rinsing and brushing of the probe. The contents of the iodine flask were quantitatively transferred to the storage container labeled with sample date, client name, and run number. A portion of the reagent was placed in a glass storage container and submitted with the samples to the Am Test laboratory for analysis for hexavalent chromium.

The bubblers and impingers utilized for the condenser section of the sample train were weighed with a readability of $\pm$0.1 grams before and after sampling on a Mettler PE3000 electronic top loading balance. The difference between the initial and final weights of the condenser section constitute the amount of moisture gain during the run. The contents of the impingers containing sodium hydroxide absorbing solution were then transferred to a 1000 ml glass graduated cylinder. The bubblers and impingers were rinsed with 0.1 N NaOH reagent into the

graduated cylinder, and the liquid level was recorded. The liquid was then transferred to the corresponding sample container for each run which contained the probe wash. The samples were submitted to Am Test, Inc.'s laboratory each day for hexavalent chromium analysis. Hexavalent chromium (Cr^{+6}) analysis was performed using EPA Method 7176, which is a diphenylcarbazide colorimetric method. The hexavalent chromium analyses were completed within 48 hours after collecting the samples. The laboratory results were presented in units of micrograms per sample. Those units were converted to concentrations in air.